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The status of zinc in type 2 diabetic patients and its association with glycemic control

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Abstract:

BACKGROUND: Zinc (Zn) is a trace element that carries antioxidant properties. Deficiency of Zn increases oxidative stress, especially in diabetes. The objective of this study was to assess the relationship between the level of Zn and glycemic control in type 2 diabetes.

MATERIALS AND METHODS: A cross-sectional study was carried out in the Department of Medicine at King Abdullah bin Abdulaziz University Hospital, Riyadh, Saudi Arabia, from March 2018 to September 2018. A total of 440 participants were included in the study; 252 of these had type 2 diabetes and 188 were controls. All participants had laboratory investigations including fasting blood sugar (FBS), glycosylated hemoglobin, and lipid profile and Zn levels. These two groups (diabetics and controls) were further divided into Zn deficient group and normal Zn group according to their Zn levels. Data were analyzed by using SPSS software.

RESULTS: The mean Zn level was 11.7 ± 1.5 in the control group, whereas it was significantly low (9.3 ± 1.6) in the diabetic group ($P < 0.001$). Zn deficiency in the control group was only 6.4%, while in the diabetic group, it was 67.9%, ($P \leq 0.001$). The mean ages for the low Zn group and normal Zn group were 40.9 ± 12.5 and 37.5 ± 10.1 , respectively, and the Zn deficient group was higher in age ($P = 0.003$). There was no significant statistical difference between genders regarding Zn deficiency. Obesity was associated with significantly low Zn levels ($P = 0.016$). The serum Zn level was significantly negatively associated with FBS and glycated hemoglobin in diabetic participants ($P < 0.001$).

CONCLUSION: Diabetic patients have Zn deficiency compared to normal individuals and poor glycemic control is associated with low Zn levels.

Keywords:

Diabetes mellitus, poor glycemic control, trace elements, zinc

Introduction

Diabetes mellitus (DM) is a growing health issue all over the world, and at present, more than 3 million people (16% of population) in Saudi Arabia have DM.^[1] In diabetic patients, chronic hyperglycemia increases oxidative stress by the production of free radicals (oxidants) and the reduction in antioxidant defense system. This leads to

oxidative cellular injury resulting in cellular dysfunctions.^[2] Zinc (Zn) is an important trace element which acts as an antioxidant to reduce oxidative stress in the human body. The deficiency of Zn is associated with many chronic illnesses like type 2 DM.^[3] There is no definite cause and effect relationship between Zn deficiency and DM. DM may cause the lowering of the level of Zn in the body by increasing its excretion and decreasing its absorption from intestines or by excretion from kidneys.^[3] The proposed

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mechanism of action of Zn is that it acts as cofactor for the synthesis of insulin, its storage, and probably its secretion from the pancreas.^[3] In type 2 DM, the main factor is insulin resistance which may be increased by Zn deficiency.^[3]

Zn has an important role in the utilization of glucose by muscle and fat cells.^[4] It is required as a cofactor for the function of intracellular enzymes that may be involved in protein, lipid, and glucose metabolism (27).^[4] Zn may be involved in the regulation of insulin receptor-initiated signal transduction mechanism and insulin receptor synthesis.^[5]

The other proposed mechanism of importance of Zn is its role as an antioxidant for the improvement of metabolic control in type 2 DM. Zhu *et al.*^[6] demonstrated that Zn supplementation in diabetic rats increased glutathione peroxidase enzyme activity and decreased the level of malondialdehyde and nitric oxide, which revealed the protective action of Zn against oxidative stress present in type 2 DM. The authors also observed that the intake of Zn improved liver functions and also prevented damage to pancreatic tissue induced by diabetes. Oxidative stress found in type 2 DM is improved by the action of Zn because it also reduces chronic hyperglycemia. Zn takes part in insulin inventory, secretion and action processes for being a catalytic cofactor for carboxypeptidase H and enzyme which catalyzes the conversion from proinsulin into insulin. Zn also promotes phosphorylation of insulin receptor by enhancing glucose transport into cells.^[7] The study by Vashum *et al.*^[8] demonstrated the role of Zn in reducing chronic hyperglycemia in type 2 DM considering that patients with higher serum concentration of Zn improved their insulin sensitivity.

The National Health and Nutrition Examination Survey for Koreans conducted in 2005 showed that the prevalence of diabetes was 9.0% for male adults and 7.2% for female adults. The study indicated that marginal Zn deficiency was more prevalent among diabetic adults than the normal adult population.^[9]

The reduced concentration of Zn in type 2 DM was demonstrated by Saharia and Goswami^[10] Al-Marouf and Al-Sharbatti^[11] also reported that Zn levels were lower in diabetic patients compared to their controls, and they found a strong negative relationship between glycosylated hemoglobin levels of diabetic patients with their serum Zn levels. Anderson *et al.* reported that 30% patients with DM were found to be Zn deficient.^[12] Tripathy *et al.* also reported Zn depletion in type 2 DM.^[13] However, Mamza *et al.* reported high Zn levels in type 2 DM patients.^[14] In view of these controversial findings in literature, we conducted this study to determine the

status of serum Zn and its relationship with glycemic control in type 2 DM. The objectives of our study were to compare the prevalence of Zn deficiency between diabetic patients and normal healthy subjects to assess the relationship between Zn levels and glycemic control. We were to look for the prevalence of Zn deficiency in diabetic patients and to discover the relationship of glycemic control with serum Zn levels. Our hypothesis was that diabetic patients had low Zn levels compared to the nondiabetic population and low Zn level was associated with poor glycemic control.

Materials and Methods

This hospital-based prospective study was done at King Abdullah bin Abdulaziz University Hospital (KAAUH), Riyadh, Saudi Arabia, for a period of 6 months (from March 2018 to September 2018). Ethical approval was obtained from the Institutional Review Board, and informed written consent was obtained from all participants.

The sample size was calculated by using a formula available on the SurveyMonkey website by keeping a 95% confidence level and 5% margin of error for an infinite number of population, The minimum sample size needed was 383 participants. For the analytical part of the study (to investigate the association between Zn and glycemic control), and assuming that 10% and 20% of those with acceptable and poor glycemic control have Zn deficiency, respectively, a total of 438 patients was needed to test the null hypothesis with a statistical power of 80%.

The patients with type 2 diabetes presenting to the outpatient department (OPD) of KAAUH were selected as cases, and signed informed consent if they agreed to participate. Patients who were pregnant, had creatinine clearance of <30, on diuretics or mineral supplements were excluded from the study. The controls were taken on voluntary basis matching with the age and gender of the cases. Good glycemic control was considered as glycosylated hemoglobin (HbA1c) 7 or less.^[15] Zn level of <10 mmol/L was considered deficiency.^[16]

We defined dyslipidemia as cholesterol <1.55 mmol/L, low-density lipoprotein (LDL) cholesterol >2.5 mmol/L, and triglycerides (TGs) >1.8 mmol/L.^[17] Regarding socioeconomic classes, we defined low economic status as having a monthly income of <4000 Saudi Riyals; middle economic status was the monthly income of 4000–9000 Saudi Riyals; and high economic status as the monthly income more than 9000 Saudi Riyals.^[18]

Data collection was done by the investigator on preformed pro forma using electronic system (Trakcare system). The age in years, gender height in meters (m),

and weight in kilogram (kg) were recorded in patient's file by two Outpatient Department (OPD) nurses in OPD triage room. Body mass index (BMI) was calculated by using formula; BMI = Weight in kg divided by height in meter square. Blood pressure was measured with adult size sphygmomanometer after 5 min of rest in the OPD. The fasting blood sample was taken on same visit for fasting blood sugar (FBS), HbA1C, thyroid profile, and lipid profile and serum Zn level. The FBS was done by the enzymatic calorimetric method and HbA1c estimation was done by fast ion exchange resin method in the same hospital. Serum cholesterol and LDL were done by cholesterol oxidase method and serum TG by glycerol peroxidase method on Auto analyzer in the same hospital. The Zn level was measured by coupled plasma mass spectrometry in other hospitals (National Guard Hospital, Riyadh). The performance of the assay was monitored by the quality control done with each batch of samples. This assay is reliable as mentioned in many studies.^[19]

The reference range for adult patients in our population is 10.09–16.83 $\mu\text{mol/L}$. The groups were divided into normal Zn ($>10 \mu\text{g/dL}$) and low Zn ($<10 \mu\text{g/dL}$) levels. Another group division was poor glycemic control group (HbA1c $>7\%$) and good glycemic control group (HbA1c $<7\%$). These two groups (diabetic and control groups) were analyzed by using the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM, USA) for Windows from IBM. The analysis was composed of two parts. The descriptive analysis was done to estimate the prevalence of poor control of blood glucose level, percentage of Zn deficiency, and frequencies of different variables. For the analytical part of the study to discover the association of Zn and poor glucose control, the Pearson's linear coefficient was utilized. The logistic regression analysis was done. First, univariate logistic regression model was performed for Zn level variables and each of the confounding variables separately to estimate the unadjusted odds ratio. This was followed by multivariate logistic regression in which all predictors were added to the model to identify independent significant risk factors. A $P \leq 0.05$ was considered statistically significant.

Results

Of the 440 participants, 57.3% ($n = 252$) had type 2 DM, while 42.7% ($n = 188$) were controls. Tables 1 and 2 show the frequency and distribution of demographic data with relation to low and normal Zn levels. There was no significant difference in diabetic and control groups regarding age, systolic blood pressure (SBP), diastolic blood pressure (DBP), LDL, high-density lipoprotein (HDL), and TG but for obese patients, higher HbA1c, higher FBS, and low Zn level were seen

in the diabetic group ($P = 0.012, <0.001, 0.015, <0.001$, respectively). The mean Zn level was $10.3 + 1.98$ in all participants and $11.7 + 1.5$ in the control group, whereas it was significantly low ($9.3 + 1.6$) in the diabetic group, and there was statistically significant difference in Zn levels between the controls and the diabetic group ($P < 0.001$). The mean ages for low Zn group and normal Zn group were $40.9 + 12.5$ and $37.5 + 10.1$, respectively. There was statistically significant difference between the two groups ($P = 0.002$) [Table 2]. Age was categorized into two groups < 50 and > 50 years, and there was statistically significant difference between the two groups, the Zn-deficient group being higher in age [$P = 0.003$, Table 2]. There was no significant statistical difference between genders regarding Zn deficiency ($P = 0.370$) [Table 1] Most participants were married (72.5%, $n = 319$). There was significant statistical difference between Zn deficient and normal Zn groups regarding marital status, and married participants were seen to be more Zn deficient ($P = 0.044$). The risk of Zn deficiency was 20% more in married participants compared to participants who were single [Tables 1 and 3]. Regarding nationalities, four hundred and seven participants were Saudis (92.5%) and there was no statistical significant difference between Zn deficient and normal Zn group regarding nationalities ($P = 0.256$). Most of the participants were from the middle socioeconomic class (62.5% compared to 21.8% and 15.7%). There was no statistical significant difference between Zn deficient and normal Zn groups regarding socioeconomic classes ($P = 0.179$) [Table 1], but there was more risk of Zn deficiency in the middle and lower classes compared to the higher class, but this was not statistically significant [Table 3]. The mean BMI for diabetic group was $30.6 + 10.5$ whereas $28.6 + 5.3$ for control group, and there was statistical significant difference between the diabetic and control groups [$P = 0.012$, Table 3] and there was statistical significant difference between the low Zn group (BMI = 30.78) and the normal Zn group [BMI = 28.99, $P = 0.028$, Table 2] The overweight and obese participants had significantly low Zn levels compared to normal-weight participants [$P = 0.016$, Table 1]. Thirty-seven hypertensive participants were Zn deficient (47.8%) compared to 42 hypertensive participants with normal Zn levels, so there was no statistical significance of hypertension regarding Zn deficiency ($P = 0.179$). Hypertension was a risk for Zn deficiency on crosstab risk assessment [Tables 1 and 3]. Fifty-two participants with dyslipidemia were Zn deficient (41.6%) compared to 73 dyslipidemic participants with normal Zn levels (58.4%), but there was no statistically significant difference in the groups with normal and low levels of Zn [$P = 0.476$, Table 1]. Those with dyslipidemia had a slightly higher risk of Zn deficiency on crosstab risk assessment (1 and 3). Serum

Table 1: Characteristics of study participants by zinc level (n=440)

	Low zinc level N (%)	Normal zinc level N (%)	Total N (%)	P-Value	OR
Age (years)					
<50	139 (38.4)	223 (61.6)	362 (82.3)	0.003	0.681
>50	94 (24.0)	112 (29.0)	78 (17.7)		1.413
Total	183 (41.6)	257 (58.4)			
Gender					
Male	20 (38.5)	32 (61.5)	52 (11.8)	0.370	0.863
Female	183 (41.6)	225 (58.4)	388 (88.2)		
Total	183 (41.6)	257 (58.4)	440 (100)		
Marital status					
Single	42 (34.7)	79 (65.3)	121 (27.5)	0.044	0.671
Married	141 (44.2)	178 (55.8)	319 (72.5)		
Nationalities					
Saudi	167 (41.0)	240 (59.0)	407 (92.5)	0.256	0.739
Non-Saudi	16 (48.5)	17 (51.5)	33 (7.5)		
Social status					
Low	42 (43.8)	54 (56.3)	96 (21.8)	0.179	-
Middle	109 (39.6)	166 (60.4)	275 (62.5)		-
High	32 (46.4)	37 (53.6)	69 (15.7)		
BMI					
<25	21 (28.0)	54 (72.0)	75 (17.0)	0.018	-
25-30	76 (47.5)	84 (52.5)	160 (36.0)	0.016	-
>30	86 (42.0)	119 (58)	205 (47.0)		
Participants					
Diabetic	171 (67.9)	81 (32.1)	252 (57.3)	<0.001	30.963
Control	12 (6.4)	176 (93.6)	188 (42.7)		
HTN					
Yes	37 (46.8)	42 (53.2)	79 (18.0)	0.179	1.297
No	146 (40.4)	215 (59.6)	361 (82.0)		
Dyslipidemia					
Yes	52 (41.6)	73 (58.4)	125 (28.4)	0.476	1.001
No	131 (41.6)	184 (58.4)	315 (71.6)		

BMI=Body mass index, OR=Odds ratio, HTN=Hypertension

Zn levels were negatively associated with FBS and HbA1c, which was statistically significant ($P < 0.001$)

Discussion

Our study revealed that diabetic participants had significantly low mean Zn levels than control subjects ($P < 0.001$). These results were consistent with a previous study done by Sahria and Goswami,^[10] which also showed low levels of Zn in diabetic patients compared to their controls ($P < 0.001$). This finding also concurred with studies done by Saha-Roy *et al.*^[20] and Masood *et al.*^[21] Al-Marouf and Al-Sharbatti^[11] also observed significantly lower serum Zn levels in diabetics than in control subjects. Marchesini *et al.*^[22] explained that low Zn seen in the diabetic population was due to the decreased gastrointestinal absorption and increased urinary excretion. In one study, the Zn levels were reported as similar in diabetic and control subjects.^[23] However, a study done by Mamza *et al.* revealed high Zn levels in diabetic patients.^[14] Having diabetes and aged 50

and over were predictors for Zn deficiency. This finding was different from the study done by Masood *et al.*, in which there was no significant difference regarding age,^[21] but Hwalla *et al.* revealed in a study that there was significant deficit of micronutrient including Zn in the elderly population.^[24]

In our study, female-to-male ratio was 7.4:1, so there were more female participants in the study. Our populations for the hospital were university staff and students and since it is a female university a preponderance of female participants in our study was to be expected. There was no significant difference in male and female patients regarding Zn levels ($P = 0.370$), which was similar to previous studies done by Sahria and Goswami,^[10] but Al-Numair showed that the serum Zn level in males was statistically significantly ($P < 0.05$) higher than females.^[25]

Most of our study participants belonged to the middle class. No statistically significant difference was found in

Table 2: Comparing means of continuous variables between diabetic and control group

Variables	Low Zinc level		Normal Zinc level		Controls		Diabetics		HbA1c <7%		HbA1c >7%		Diabetic		Control		
	Mean±SD	P-Value	Mean±SD	P-Value	Mean±SD	P-Value	Mean±SD	P-Value	Mean±SD	P-Value	Mean±SD	P-Value	Mean±SD	P-Value	coefficient	P-Value	
Age	40.91±12.533	0.002	37.54±10.137	0.002	40.29±11.901	0.004	37.13±10.206	0.004	40.70±11.812	0.712	40.10±11.972	0.712	40.10±11.972	0.227	0.039	0.594	
BMI	30.78±11.298	0.028	28.99±5.410	0.028	30.60±10.049	0.012	28.57±5.313	0.012	29.16±4.832	0.121	31.27±11.663	0.121	31.27±11.663	0.771	-0.076	-0.076	0.376
SBP	119.72±13.301	0.329	118.48±12.821	0.329	119.70±13.017	0.191	118.06±13.005	0.191	118.84±12.035	0.473	120.11±13.467	0.473	120.11±13.467	0.818	0.015	-0.77	0.296
DBP	70.72±9.632	0.049	68.99±8.608	0.049	70.18±9.205	0.208	69.08±8.888	0.208	69.13±8.089	0.214	70.67±9.664	0.214	70.67±9.664	0.479	-0.045	-0.065	0.376
FBS	7.123±9.7275	0.006	5.357±1.0253	0.006	6.767±8.3943	0.015	5.210±0.6534	0.015	-	-	-	-	-	0.001	0.017	0.017	0.823
HbA1c	8.387±1.7200	<0.001	6.027±1.0233	<0.001	8.092±1.6198	<0.001	5.556±5.230	<0.001	-	-	-	-	-	<0.001	-0.472**	-0.045	0.544
HDL	1.353±.3315	0.849	1.346±0.3717	0.849	1.374±0.3608	0.092	1.316±0.3457	0.092	1.384±0.3513	0.751	1.369±0.3660	0.751	1.369±0.3660	0.411	-0.052	-0.117	0.341
Triglyceride	1.174±0.5590	0.782	1.159±0.6016	0.782	1.172±0.5402	0.766	1.156±0.6386	0.766	1.200±0.5480	0.581	1.160±0.5376	0.581	1.160±0.5376	0.609	0.032	0.019	0.801
LDL	2.990±0.8212	0.794	2.970±0.7948	0.794	2.969±0.7827	0.788	2.990±0.8358	0.788	2.883±0.7079	0.234	3.009±0.8142	0.234	3.009±0.8142	0.312	0.064	-0.117	0.110
Zinc	-	-	-	-	9.255±1.6280	<0.001	11.699±1.4846	<0.001	10.348±1.4668	<0.001	8.746±1.4411	<0.001	8.746±1.4411	-	-	-	-

** : Statistically significant (P ≤ 0.05). HbA1c=Glycated hemoglobin, BP=Blood pressure, SBP=Systolic BP, DBP=Diastolic BP, BMI=Body mass index, HDL=High-density lipoprotein, LDL=Low-density lipoprotein, FBS=Fasting blood sugar

the Zn levels of the socioeconomic classes ($P = 0.179$), but low and middle classes had a higher risk of Zn deficiency compared to the high class. Al-Numair also revealed that there were no significant differences in serum Zn levels as regards socioeconomic status.^[25]

In our study, there was a significant difference in Zn levels regarding the BMI of the participants, and overweight and obese participants had significantly low Zn levels ($P = 0.016$). This was consistent with the study by Marreiro *et al.*^[26]

Most of our participants were married (72.5%), and they had low level of Zn compared to single participants ($P = 0.044$). This result is similar to the study from Pakistan, in which there was a significant decrease ($P < 0.03$) in Zn concentration in married women compared to unmarried women.^[27] We excluded pregnant females from our study population because a previous study from the same country had revealed 85% pregnant ladies with Zn deficiency.^[28]

Hypertension was found only in 18% of participants, and they had high risk of Zn deficiency compared to nonhypertensive participants. Furthermore, in this study, the systolic and diastolic blood pressure were negatively correlated with serum Zn level (SBP “ r ” = -0.056, DBP “ r ” = -0.78, $P = 0.243, 0.10$, respectively). A study on type 2 diabetic patients to see the effect of vitamin/minerals (including Zn) on blood pressure revealed there was significant improvement in blood pressure after vitamin/mineral supplements.^[29]

In our study, dyslipidemia was found in 28.4% of the participants, and they had slightly higher risk of Zn deficiency compared to nondyslipidemic participants. Furthermore, in our study, the serum Zn level was negatively associated with LDL ($r = 0.039, P = 0.413$), HDL ($r = 0.028, P = 0.559$), and TGs ($r = 0.022, P = 0.650$) levels. The study done by Seo *et al.*^[30] revealed that serum Zn levels in men were negatively associated with elevated FBS and positively associated with elevated TGs. On the other hand, the same study^[30] showed a negative association between serum Zn and HDL cholesterol levels in both men and women. The effect of Zn on lipid profile and blood pressure was documented also in some other studies. Ghasemi *et al.*^[31] found a positive correlation between serum Zn levels and TGs in Iranian men, whereas no association was observed between serum Zn concentrations and lipid profiles in a Lebanese population.^[32] It was observed that the mean fasting blood glucose in type 2 DM cases was found to be very significantly higher than that of the controls ($P < 0.001$). The FBS was negatively correlated with serum concentration of Zn ($r = 0.478, P < 0.001$), which was dissimilar to the study done by Mamza

Table 3: Univariate and multivariate regression analysis for association between independent variables zinc level

Variable	Univariate			Multivariate		
	OR	95% CI	P-Value	OR	95% CI	P-Value
Age <50 years	0.482	0.294-0.790	0.004	0.502	1.0-2.827	0.050
Male gender	0.86	0.476-1.562	0.626	1.212	0.519-2.827	0.657
Marital status single	0.671	0.435-1.037	0.072	0.880	0.477-1.620	0.681
Nationality Saudi	0.74	0.363-1.505	0.405	0.750	0.283-1.991	0.564
Socioeconomic						
Low	1.185	0.740-1.895	0.480	1.187	0.511-2.758	0.691
Middle	0.899	0.483-1.675	0.738	1.584	0.777-3.230	0.206
Hypertension	1.297	0.795-2.116	0.297	0.951	0.472-1.771	0.791
BMI						
Normal	0.430	0.238-0.777	0.005	1.048	0.485-2.264	0.906
Overweight	0.538	0.303-0.957	0.035	0.517	0.294-0.910	0.022
Diabetes	30.963	16.298-58.823	<0.001	0.30	0.015-0.058	<0.001
Dyslipidemia	1.001	0.657-1.523	0.735	0.735	0.427-1.265	0.267

BMI=Body mass index, OR=Odds ratio, CI=Confidence interval

et al.^[14] ($P = 0.334$) and Masood *et al.*^[21] ($P = 0.81$), in which there was no relation of Zn concentration with FBS.

The Zn level was significantly low in a group of poor glycemic controlled diabetic participants compared to diabetic participants with good glycemic control ($P < 0.001$). This agrees with the study by Bandeira^[33] which revealed that plasma Zn level was inversely related with glycosylated hemoglobin in type 2 diabetic patients ($r = 0.318$, $P = 0.004$). The same results were shown in a local study^[34] in Saudi Arabia which revealed that high HbA1C was associated with low Zn levels.

Regarding the duration of DM, anything <10 years had less risk of Zn deficiency than a duration of more than 10 years, so the longer duration of having diabetes was associated with low Zn level. This is because the longer duration of diabetes causes poor glycemic control, which is inversely related with Zn level. In the present study, it was observed that serum Zn level was negatively associated with FBS and HbA1c ($P < 0.001$). This means that when there are lower values of HbA1C, the values of serum Zn concentration are higher and vice versa. The Pearson correlation coefficient “ r ” was found to be -0.635 , which also established the strong negative correlation between these two parameters ($P < 0.001$). Sahria and Goswami^[10] (4) also reported a negative relationship between HbA1c and Zn concentration with “ r ” value of -0.804 . Tripathy *et al.*^[7,13] found a significant negative correlation between serum Zn and HbA1C percentage (“ r ” = -0.408). Al-Marouf and Al-Sharbatti^[11] found a significant negative correlation between serum Zn concentration and HbA1c% value in the diabetic group and found the correlation coefficient “ r ” to be -0.33 .

This Zn deficiency can be counterbalanced by Zn replacement as research has revealed that there are health benefits for healthy individuals, and has also demonstrated the protective effect of Zn for diabetic patients.^[35] A study by Zhu *et al.*^[36] on diabetic mice demonstrated that the Zn supplementation increased the activity of superoxide dismutase and decreased malondialdehyde concentrations in both serum and pancreas.

There were some limitations of our study. First, since it was cross-sectional study cause and effect relationship between diabetes and low Zn level could not be established. Second, in this study, other minerals such as magnesium, chromium or copper were not done concurrently with Zn levels to know the influence of these trace elements on serum Zn level. Therefore, the low Zn levels could be due to some effects of other minerals particularly copper. Third, the history of diet which could have some effect on serum Zn levels or glycemic control was not included. Furthermore, the analysis did not include diabetic medications which would have some effect on glycemic and Zn levels, although all participants received standard management by endocrinologist in diabetic and endocrinology clinic in our hospital. Finally, the history of iron intake which has some effect on absorption of Zn from intestines was not included. Despite these limitations, this is one of the few studies done in a Middle East population and could be first study from Kingdom of Saudi Arabia with a good sample size and strong study power. The study not only showed the relationship of FBS and HbA1C but also revealed relationship of SBP, DBP, LDL, HDL, and TG levels. Therefore, an acceptable sample size, a good match of diabetic and control participants, showing relationship in coefficient significance and 80% power of study are the strengths of this study.

Conclusion

Our study concludes that population with diabetes have low Zn level compared to healthy population. This significantly low levels of Zn could be the cause of the development of diabetes or possibly diabetes is causing Zn deficiency, the cause and effect relationship was not established. There was a negative relationship between serum Zn and FBS and HBA1C, so low Zn levels were associated with poor glycemic control and poor glycemic control is a strong predictor of Zn deficiency. The other strong predictors of Zn deficiency were increasing age, female gender, obesity, being married, and low and middle socioeconomic classes. The weak predictors were hypertension and dyslipidemia. This study adds to the hypothesis of an association of Zn deficiency with type 2 DM. We suggest further studies designed as case-control or cohort studies to evaluate cause, affect relationship between Zn levels, and type 2 DM. We recommend a check on the Zn levels in diabetic patients if they have poor glycemic control, longer duration of diabetes, obesity, aged more than 50 years, so that Zn replacement therapy may be initiated to reduce oxidative stress in this high-risk population.

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Conflicts of interest

There are no conflicts of interest.

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